after a signal to seek food. The authors also report that, "For any given power density, ressponse rates were generally lower following exposures to pulsed waves than following exposures to continuous waves." (Thomas, 1982, 67)

8). Disruption of rats being able to learn new tasks or be able to perform learned tasks which require learning a complex 4 step sequence of tasks. (Schrot, 1980, 66) — 18%

9). Disruption of learned behavior when a medication for treating Attention Deficit Disorder, Dextroamphetamine, was given to rats. Rats had trouble waiting a fixed time after a signal to get food in comparison to non-exposed controls. The rats were exposed 4 days a week, and tested on a day when there was no exposure. Hence, the authors conclude any effect would be evidence of cummulative effects. (Thomas, 1979, 67) — 5%

10) Apparent damage to barrier protecting the brain from certain molecules in the blood. Occurred a power levels too low to be an artifact of temperature effects, as it was subsequently learned had occurred for higher power levels. The study was never completely replicated. It was hypothesized (NCRP 1986, pg.) that the effect may have resulted from the 5 pulses per second pulse rate similar to pulse rates at which other very low power effects have been found. (Oscar, 1977, 66) — 0.25%

11) Ulrastructure changes in hippocampus part of brain is attributed by the author as "can most probably effect their function and consitutes one of the elements of pathogenesis of early disturbances in people exposed to this environmental factor." (Belokrinitskiy, 1982, 61) — 0.15%

- **Lack of a science based approach due to IEEE 1991 presuming cell culture findings represent effects which are "transient and reversible with no detrimental effects" - even when study authors considered the effect detrimental.**

IEEE 1991 states, *"Studies, such as thosse indicating effects, in vitro, on cell function were considered transient and reversible with no detrimental effects."* [IEEE 1991 pg. 27].

Below are some in vitro studies whose authors believed finding represented an adverse effect or suggested the potential for adverse effects

1991 **Cell culture studies included:**	% of IEEE hazard threshold
Disruption of nerve signalling where *"it is almost certain would be disruptive of ongoing information handling if they were to occur in an intact nervous system."* (clearly an adverse effect) The author also indicated	25%

that effects may be permanent under chronic exposure conditions. (Wachtel, 1975, 68) Based on results it was hypothesized that at a dose rate (of 25% of the IEEE hazard level) would be sufficient to affect the firing rate of pacemaker neurons. (EPA 1984. pg 5-9)

Indication of suppressed immunity found (Liburdy, 1985, 65) 4.25%

Calcium ion concentration by surface of human brain cells (federal health agencies do not consider this an adverse effect because its implications are not known. But it is known that these ions *"are important in the regulation of cell function and normal development."* (Dutta 1984, page 63 on IEEE final list) 1.25%

Also consider *"Collectively, the data suggest a possible role for calcium ions in the process of skin tumor promotion by anthrones (a class of tumor promoters which generate free radicals)."* [Battalora, 1995, pages 19-25]

Also a study finding an association between Alzheimer's disease and electromagnetic fields noted that an inbalance of calcium ions can cause cell death. (Sobel, 1995)

There are credibility problems due to federal agencies stating important available studies finding adverse effects (cancer) were not considered

Two studies not reported in the IEEE final list of papers showed the following effects, with the corresponding exposure in terms of the percent of the IEEE 1991 hazard threshold.

2 Studies available to IEEE 1991 but not included in its final list:	% of IEEE 1991 hazard threshold
#1. 25 months chronic study of rats exposed to RF and with statistically significant results finding a more than 3 fold increase in primary malignant tumors aggregated from all sites. (Kuntz 1985, Chou 1992, and reviewed in NCRP 1986)	10%

Concerning this study the FDA Center for Device and Radiological Health reported in an FDA report,

"Although this study has been discounted by some critics because no one tumor site or target organ predominated, this is precisely what one would expect for an agent which accelerates the progression of naturally occuring malignant cells."

(and later in the same report the FDA concludes) *"The fact remains, however, that the data which exists strongly suggests that microwaves can, under at least some conditions, accelerate the development of malignant tumors. This in vivo (animal) data is also supported by in vitro (cell culture) data which has demonstrated not only malignant transformation but other effects on the cell's growth control mechanisms."*

letter of D. Fichtenberg to Chairman Hundt, July 30, 1996

[in Appendix 5, Potential Public Health Risks From Wireless Technology (1994), published by Scientific Advisory Group on Cellular Telephone Research (now Wireless Technology Research Limited Liability Company), 1711 N Street NW Suite 200, Washington DC 20036, tel: (206) 833-2801]

Hence, it is expected that EPA and FDA were considering the above study when they wrote to the FCC,

EPA: *"a small number of reports suggesting potentially adverse effects (cancer) may exist.*.[EPA letter of M. Oge to FCC Nov. 9, 1993]

FDA: *"...very few research studies of long-term, low-level exposures of animals were included in the scientific rationale for the standard, despite the existence of animal studies that suggest an associatioin between chronic low level exposures and acceleration of cancer development. Other studies have been published since finalization of the standard that strengthen this concern.* "[Letter of Nov. 10, 1993, from L. Gill of FDA to FCC].

#2. Laboratory rats were taught to respond to a signal after waiting a certain amount 17.5%

of time. They were also given a signal just before an electric shock, so they could learn to go to a safe area. Finally, their sensitivity to electric foot shock was tested. For all 3 measures RF exposed animals showed effects: changed sensitivity to shock, poorly learning to go to a safe place prior to an electric shock, and decreased ability to perform a learned skill. (D'Andrea, 1986)

Subsequently, based on the above study it was concluded, *"...it is possible to specify that a threshold for significant behavioral effects at 2450 MHz is between 0.4 and 0.7 Watts/kg (e.g. 10% and 17.5% of the IEEE hazard threshold).* " [D'Andrea and de Lorge, 1990]

Had IEEE 1991 followed the above logic, then the IEEE 1991 threshold would be between 10% and 17.% of its present value. Of course, had IEEE been willing to select a threshold for disruption of a learned skill based on the lowest exposure where disruptions occur, then they would have chosen a level 5% of their selected threshold (see study #9, Thomas 1979, on page 8)

There are credibility problems because recent studies at exposure levels below the hazard level of IEEE 1991 have identified adverse effects. These include cancer, DNA breakage, eye lens lesions, learning deficits, brain damage, fetal anomalies, and sleep disturbaces. Many of these were also at exposure levels claimed 'safe' for people by IEEE 1991

Effect	% Exposure was of 4 W/kg
"More distinctly altered" chromosome rearrangements (Sarkar, 1994)	30%
DNA breakage (Lai, 1995)	15%
Learning difficulties/spatial memory deficit [Lai, 1993]	15%
Review article of behavioral disruption among laboratory animals, *"Based on the results of these studies, it is possible to specify that a threshold for significant behavioral effects at 2450 MHz is between 0.4 and 0.7 W/kg."* (Review is by the ***same*** 2 authors whose reports were used to	10%

determine the current IEEE 1991 hazard threshold of 4 W/kg.)
[De Lorge and D'Andrea, 1990]

Physiotherapists using microwave diathermy have greater than miscarriage rates greater than 200% of controls, while those using short wave diathermy show no increased miscarriage rates (assumes exposure meets ANSI 1982 requirements) (Quellet-Hellstrom et al. 1993)

Eye lens lesions for non-human primates given medication (timolol maleate) to treat glaucoma [Kues, 1992]	6.25%
Change in sleep patterns, onset of sleep, length of sleep [Reite 1994] [local brain exposure was 2.5% of IEEE hazard threshold for whole body exposure] Effects only occurred under certain modulation patterns. Effectiveness for inducing sleep met U.S. Patent Office evidence requirements to demonstrate the patent performs a useful purpose. (this U.S. Patent Office finding seems to invalidate claims in IEEE 1991 that *non-thermal effects* do not meaningfully relate to human health [IEEE 1991 pg. 23]	2.5%
Study participants kept a 'health' diary including sleep patterns and health related matters.Reports of difficulty falling asleep and maintaining sleep increased with proximity to a short wave transmitter. Those over 45 were more affected. Significance was added to the association when improved sleep patterns were reported when the transmitter was turned off (but unknown to the study respondents) [Apter et al. 1995]	presume less than 2% (current IEEE 1991 limit)
Damage to the blood-brain barrier protecting the brain from damaging molecules in the blood [Salford, 1993]	0.4%
18% reduction in REM sleep time and alteration of EEG during REM sleep. *"REM sleep plays a special physiological role for information processing in the brain. Here selecting, sorting and consolidating of new experiences received during the waking state were performed as well as linking them together with old experiences."* [Mann, 1996]	0.2%
2 fold increases in childhood leukemia from TV broadcast facilities "Children who lieved in communities closest to 3 broadcast towers which housed 4 TV stations and an FM radio station had more than twice the rate of leukemia compared to similar children living some 7 1/2 miles away." [Microwave News, November/December 1995]	0.2%

Non-statistically significant findings which are consistent with adverse effects
(e.g. variability too great to distinguish a real effect from chance)

1. Skin tumor area increases of about 30% (Santini, 1988)	30%
2. Brain tumor area increases of 50% were observed in laboratory animals	0.4%

exposed to 915 MHz pulsed signals with pulses between 3 and 100 per second (for this range NCRP 1986 would require occupational exposure levels to be as low as the general population exposure rates). However, authors note,

"It is noteworthy that for some modulation frequencies the average tumor size in the exposed animals largely exceeds the average tumor size in the controls, ...This might indicate that in the few animals that, for some reason, are sensitive to the exposure, tumor growth is stimulated strongly." *(Salford, 1993)*

Electromagnetic interefence (EMI) can be a safety issue as well as a 'quality of life' issue and should be addressed by the standard.

A safety concern: For the frequency range 26 MHz to 1000 MHz (e.g. including cellular phone frequencies) the International Electrotechnical Commission's (IEC) standard No. 601-1-3 (1992) requires medical devices to be immune from intereference when subjected to fields of 3 volts per meter, which corresponds to a power density of 2.4 microwatts per sq. cm. This power density indicates how low exposure may need to be to prevent malfunctions of such equipment, especially if the user is unaware of the EMI possibility - which may occur as more sophisticated medical equipment is being placed in the home.

In this regard, two managers of radio engineering laboratories of an Australian and United Kingdom telecommunications companies, did an investigation regarding what should be the exposure levels which are feasible and also provide protection from electromagnetic interference.

Dr. Ken Joyner, Manger EMC (electromagnetic compatibility) section of Telstra Research Laboratories, Australia and Dr. John Causebrook, Technical Manager, Radioengineering, Vodafone, Ltd, United Kingdom report as follows:

"We have conducted extensive testing of the potential of cellular telephones to interefere with the operation of medical electrical equipment and consulted with manufacturers of that equipment. Our conclusion is that medical electrical equipment should not be exposed to levels above 1 V/m (1 Volt per meter) from mobile radio intallations."

"We ensure that protection is provided by, first, designing our antenna installations with a rule that no area that is likely to have sensitive medical equipment will have a field strength of greater than 1 V/m. This can be achieved by transmit power control and suitable antenna design and positioning. Second, we confirm that the 1 V/m criterion is adhered to through measurement at the site." [Microwave News May/June 1996]

A "Quality of Life" concern regarding telephone interference: A Sympoisum on Wireless Transmission Base Station Facilities was held October 28, 1994 under the auspices of Federal Focus, a non-profit organization. Many telecommunications companies participated. In the Federal Focus report (1995) it stated,

"Modern telephones and telephone answering machines contain electronic circuit, but many have little if any shielding. Very long wires connect such devices to the public telephone network, and such wires can act as efficient antennas for RF energy. Also the wires in a cord several feet long that might run between the hand-piece and the phone body can also act as

antennas. Not surprisingly, telephones and aswering machines can be vulnerable to audio rectification interference."

"One Symposium participant with extensive field experience in the deployment of base stations remarked that interference to consumer grade telephones was the most frequent intereference problem he had encountered ..."

"The remedies are shielding and filtering, just as with home stereo system components....the responsibility for solving the problem lies with the purchaser (of the phone)" e.g.with the user of the phone, be it in a home or a small business.

Is it right that due to the installation of a wireless base station, that surrounding homeowners should bear the costs of the remedy? In a low income area, residents may not be able to afford the costs, or landlords of low income housing may not want to bear the costs of the remedy. How will this issue be addressed?

Hearing aid interference and 'quality of life': It has been already reported to the FCC that above 4 Volts per meter of some RF electric fields can cause significant interefence from hearing aids. This level is far below the limits in the FCC proposal. It is difficult to shield a hearing aid. Purchasing a new one with a proper filter can be very expensive. This can especially impact on senior citizens and low income persons. Is it fair that these should bear the costs or loss of good hearing quality due to a nearby base station?

A potential health concern: If the user of a telephone system is unable to afford or unwilling to remedy the interference problem, since telephone wires can act as an "efficient antenna" as above, then may the RF signal come through the wire and affect the electromagnetic field around the hand-set that is placed by the ear? Those who speak long periods may be at an increased risk. Under 'worst case' conditions, e.g. a home is near a low height base station and its telephone wires pass through the field to maximally act as an antenna, what could be the strength of the electric field in a phone handset?

Recommendation on interference: Per K. Joyner above, since there can be sensitive medical equipment in residential areas, the FCC should put a limit of 1 V/m in residential areas and near hospitals and any other kind of medical facility, and perhaps in areas where there is sensitive scientific equipment (e.g. high technology parks etc.)

The approach of two tiers "controlled" and "uncontrolled" should be rejected

The fundamental organization of the standard into two tiers of 'controlled' and 'uncontrolled' environments, where the IEEE standard states that

"[c]ontrolled environments are locations were ther is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment, by other cognizant persons, or as the incidental result of transient passage through areas where analysis shows the level may be above [the exposure and induced current levels permitted for the more restrictive limits but above those permitted for persons aware of the potential for exposure."

Finally, IEEE 1991 places the authority of deciding which environment applies with the operator creating the RF exposure [IEEE 1991, pg. 13, footnote 3]. Giving discretionary authority to the source of a hazard to increase the allowed levels by 5 fold, and just by making persons aware of the exposure, is incompatible with public health practices and policy, and should not be permitted. This is also the finding of EPA which objected to this provision.

In their letters responding to the FCC the EPA, NIOSH, and OSHA all strongly object to this entire approach because awareness alone does not provide protection - whether employed or elsewhere. Also awareness can occur in all manner of degrees and is difficult to measure. Also, objectionable was allowing the identification of these areas to be at the discretion of the operator of the source.

Places of public transit should likewise be at the exposure level for the general public. The public, including infants, the elderly, ill and disabled, can be a considerable time in parks, beaches, bus stops, airports, walking in retail business areas, or even on the sidewalks of residential areas, and should not be subject to higher levels because of this. Places of public transit should be kept desirable places to be - this is where commerce, recreation and other key activities occur. OSHA believes the higher exposure should only occur in a setting where there is a health and safety program to mitigate effects - exposing the general public in public places of transit would thus be inappropriate and reduce the quality of life in public areas of residential streets and in retail business areas where a high quality of life and pleasant (and not heated) environment exists.

Hence EPA states, *"We recommend against the use of controlled and uncontrolled environments and recommend consideration of the 1986 NCRP as a means of avoiding this problem.*

EPA also would add additional safety features not in NCRP, such features to protect against high induced or contact currents. EPA also adds, that non-technical employees may also be treated as the general public, e.g. those for whom there is not a RF health and safety program as OSHA has recommneded, see below.

Similarly OSHA says, "The possible implication that employees may be subjected to a higher level of risk because they 'are aware of the potential for exposure as a concomitant of employment' is unacceptable to OSHA."

Likewise NIOSH says, that this controlled/uncontrolled approach is *"problematic,"* and states the *"Therefore, the conservative public health approach would be to adopt only the more restrictive ...limits for all exposed workers and the general public."*

Thus, there is near unanimous agreement that the basic two tier limit structure of the IEEE 1991 standard is not acceptable.

Consider that NIOSH, OSHA, and EPA all reject basing these tiers on the IEEE definition, and so should the FCC. The approach recommended by the EPA, and OSHA, and offered in the FCC proposal is the correct one. Identify the more conservative tiers with the general population and non-technical employees, and identify the upper tier with employees for whom there is a health and safety program according to the recommendations of OSHA. Indeed, it has been found quite workable to define populations in terms of the work environment where OSHA and NIOSH place emphasis, and the general population environmental exposure and exposure to devices where

EPA and FDA put emphasis. Hence, this approach is more realistic than the vague application of 'controlled' and 'uncontrolled' concepts of IEEE 1991

Reject increasing exposure for millimeter and near millimeter waves Increasing exposure for short millimeter waves and near millimeter quasi-optical waves by 200% over current FCC limits is expected (1) to make people feel too warm or hot and should be rejected, and there are positive indications to suspect this level may have a disturbing effect on the eye, and (3) have other adverse effects.

(1) Reasons why 10 mW/sq. cm is expected to make people feel too warm

5 primary references on millimeter wave exposures were identified in the IEEE - 3 on its final list of papers, and two in its Bibliography, one a reference on the standard for the safe use of lasers, and one by Gandhi 1988 "Advances in Dosimetry of Radio-frequency Radiation and their past and Projected Impact on the Safety Standards."

The findings of each of these much better support the EPA recommended general population limits than those chosen by IEEE 1991. These papers (1), (2), (4), and (5) below assme that the human body absorbs millimeter waves in a manner similar to absorbing infrared radiation - which is also assumed by IEEE 1991 which states,

"Since the penetration depth at frequencies above 30 GHz is similar to that at visible and near infrared wavelengths, the literature for skin burn thresholds for optical radiation is expected to be applicable. [IEEE 1991 pg. 33]

Accordingly it is appropriate to consider these references.

(1) A IEEE final list paper [Gandhi and Riazi, 1986, in IEEE pg. 64] notes experiments in which study subjects reported a "detection of warmth" at 67% of the exposure permitted by NCRP 1986, and a "marked sense of warmth" at levels 84% of NCRP 1986. Gandhi et al. also note that at 87% of the IEEE 1991 limits at infrared exposure people felt 'very warm to hot.' It was noted that clothes block infrared but not millimeter waves. Hence, clothes could act like a 'green house' and trap the heat, "resulting in ...the sensation of "very warm to hot" at power densities that are lower than those quoted above." See (5) below where Gandhi recommends adopting the NCRP limits above 5900MHz due to these findings.

(2) Another paper IEEE final list paper [Justesen, et al 1982, IEEE pg. 64] report people have a perception of warmth on the ventral surface of the arm at 17% of the IEEE 1991 limit for whole body exposure. Since it is known there is thermal summation when more of the body is irradiated it seems that the EPA recommended limits are more reasonable. Certainly it is appropriate that the exposure for the general population be lower, or at most not much higher than the threshold for warmth.

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(3) Finally, a third IEEE final list paper [Deichman, 1959] exposed chicks and rats to 12.5 millimeter waves at exposures no more than 2 fold that proposed for people, and found "muscular flaccidity" among the chicks and mild hyperpyrexia (high fever or temperature) at the interface between the brain and skull of rats. While effects on humans are expected to be different given the difference in body shape, size, and thermoregulatory system, still it would seem that one

would want an 'uncertainty' or safety factor of at least 10 or so for general population exposure. Indeed, the limits of the EPA relative to this exposure is lower by a factor of 20, and from this perspective, more appropriate and science based than that of IEEE 1991.

(4) IEEE 1991 justifies its power density limit for the higher frequencies stating,

"Thus, the averaging time and the MPE(10 mW/sq. cm), at 300 GHz, are consistent with the averaging time and the MPE (for the same frequency) specified in ANSI Z136.1-1986 (the standard for the safe use of lasers)." [IEEE 1991, pg 33]

While the standard for the safe use of lasers does indeed permit the exposure stated in IEEE 1991 for millimeter exposures at the higher frequencies, it also states for this exposure level that,

"Exposure to levels at the MPE (maximum permissible exposure) may be uncomfortable to view or feel upon the skin. Thus, it is good practice to maintain exposure levels as far below the MPE as is practicable." [ANSI Z136.1-1993 (a later revision), section 8, pg. 31].

This view of the IEEE 1991 exposure level for millimeter waves also supports that of Gandhi, 1986 above - that it is expected to make people feel uncomforatably warm - and it is not expected that the FCC wants to approve criteria for the general population which is expected to make people feel uncomfortable.

[note that ANSI Z136.1-1993 and -1986 are primarily for an occupational setting. A "Special Section" addresses exposing the public who voluntarily come for a laser performance. Its exposures were not designed for 24 hour continuous exposure of the general population who may be exposed against their will or who may be especially sensitive to heat.]

(5) In Gandhi (1988) "Advances in Dosimetry of Radio-frequency Radiation and their past and Projected Impact on the Safety Standards," Gandhi reviews the above concerns and explicitly recommends the NCRP 1986 standard for above 5900 MHz. Below this, his recommended exposure limits are less than both NCRP 1986 and IEEE 1991.

Hence, there appears to be consistent agreement from the sources cited in IEEE 1991 that the level it chose for general population exposure is inappropriate. Accordingly, it is unclear in what manner IEEE 1991 members reviewed these IEEE final list papers and reference, since the recommended IEEE 1991 limit seems to contradict the science based findings in these sources, as far as there being appropriate for 24 hour exposure of the general population.

Subsequently, Gandhi recommended using the EPA recommended NCRP limit for the higher frequencies about 5900 MHz, and prepared a paper explaining his rationale. Moreover, it is all the more unclear why IEEE 1991 chose the standard it did, since IEEE 1991 references this very paper (as IEEE [26]) in which Gandhi advises against adopting the limit that IEEE 1991 eventually selected. Hence, it is unclear why IEEE 1991chose the higher limit, given the foregoing which suggests the opposite path was in accordance with public health concerns and science facts.

(2) Reasons why for 10 mW/sq. cm there are positive indications to suspect this level may have a disturbing effect on the eye

1. As noted above, the ANSI Z136.1-1986 and -1993 standard explicitly state that it is expected to be umcomfortable "to view" at this exposure level, and states

"Exposure to levels at the MPE (maximum permissible exposure) may be uncomfortable to view or feel upon the skin. Thus, it is good practice to maintain exposure levels as far below the MPE as is practicable." [ANSI Z136.1-1993 (a later revision), section 8, pg. 31]. see Exh 7.

Thus, while the standard referenced by IEEE 1991 does not explicitly state that every one of its limits was expected to be uncomfortable to view, the statement certainly provides a positive indication to suspect that this effect may occur at any of its limits, and in particular for a 1 millimeter wave, and that which is uncomfortable is, necessarily a disturbance.

2. *"Based on the exposed section of the human eye, we estimate a power absorption on the order of 15-25 mW for an incident power density of 10 mW/sq. cm.. This may imply a potential problem for the ocular apparatus as a consequence of millimeter wave irradiation. Even though the injuries observed in (Rosenthal et al. 1976) we found to be reversible and vanished after 24 to 48 hours after exposure, the effects may be more serious and nonreversible in the case of long term exposures."* [Gandhi O.P. and Riazi A. 1986, on IEEE 1991 final list page 64]

In the referenced study inflamation of the cornea of the eye characterized by burning or smarting, blurring of vision (keratitis) was the first disease condition to occur, and Dr. Gandhi above, determined that at 10 mW/sq. cm. the human eye will be exposed to approximately the same order of magnitude which caused the keratitis. Hence, based on this independent source there is a positive indication to suspect a 10 mW/sq. cm will have a disturbing effect upon the eye.

- In a <u>letter to the Commission</u> [dated March 4, 1996] concerning this Rosenthal et al (1976) study an opinion expressed to the FCC that,

  "This (no peer review), in combination with the age and obscurity of the source, raises questions about any conclusions based upon the article."

These are interesting comments. Generally the simple passage of time does not alter scientific relationships found. For this reason IEEE 1991 apparently still found published reports as old as this paper relevant since of the 120 IEEE final list papers reviewed to prepare the standard, 14 were published in 1976 or earlier, the same year as the Rosenthal et al paper (note the abstract was published in 1975) and include:papers of 1 Birenbaum, 2 Cogan, 3 Czerski, 4-5 Deichmann (2 papers), 6 de Lorge, 7 Elder, 8 King 9 Liu, 10 Moe, 11 Phillips, 12 Tinney, 13 Wachtel, and 14 Wangemann. This is over 10% of the IEEE final papers Clearly IEEE did not find papers published by 1976 too old to consider

Moreover, concerning the *"obscurity of the source,"* it is noteworthy that 3 of the IEEE final list papers were selected from this same source and included the papers of de Lorge, Elder et al, Moe et al. Indeed, that from a single conference should come 3 of the 120 IEEE final list papers reviewed for the standard is quite a distinction for the conference indicating its quality and significance. (It is unclear why the Rosenthal paper was not also selected, but others have found it a weakness in IEEE 1991 that important papers were not considered - as noted elsewhere in this report.) Moreover, the conference was sponsored by a committee of the National Academy of

Sciences, and in addition the Food and Drug Administration published the proceedings. Finally, consider that in 1993 the International Radiation Protection Association, the United Nations Environmental Programme, and the World Health Organization publised Environmental Health Criteria #137: Electromagnetic Fields (300Hz to 300 GHz); this report listed only one paper above 10 GHz which studied RF effects on the eye- the paper of Rosenthal et al. (1976) (see WHO Report #137, pg. 120 and 122, Tables 15, 16] Given the above, the reader should determine if this was an "obscure" soucre or not

3. Subsequent studies at lower frequency show damage to the eye at 10 mW/sq. cm of power or less when monkeys are treated with timolol maleate, a medication used to treat glaucoma. Since higher frequency tends to concentrate power closer to the surface one may expect, until shown otherwise, that also at higher frequencies would timolol-maleate treated monkeys suffer eye damage. Specifically, a study by Kues et al (1992) reported that at 10 mW/sq. cm an estimated local specific absorption rate (SAR) was 0.26 W/kg caused damage to the iris of timolol treated monkeys. The authors also suggest that serum protein leakage could have contributed to the corneal endothelial lesions observed in an earlier paper (Kues, 1985) at a pulsed wave with a frequency of 2450 MHz and average power density of 10 mW/sq. cm.. Since at this frequency there is penetration into the eye, probably less than a small part of the energy will be absorbed by the corneal endothelial tissue. Accordingly, since at a higher higher frequency of 60 GHz or so almost all of the energy will concentrate on the cornea and its endothelial tissue, one would expect there more likely to be lesions. A study of this question would be helpful and be more sensitive if pulsed waves and timolol-maleate would be used in the manner that gave positive results before.

Moreover, numerous effects on single cells and molecules are listed in studies below identified in NCRP 1986. These effects could presumably also affect eye tissue. See effects in near millimeter and millimeter list below.

Consequently, the levels recommended by EPA or lower should be the only options the FCC should consider. However, the EPA recommeded standard still permits the general population to be exposed to a perception of warmth, and hence is too high. The 1986 British standard of its National Radiological Protection Board may have considered this [Gandhi 1990, pg. 21-22, for the NRPB (1986) standard] when setting its standard of 0.4 mW/sq. cm. below the limit [Justesen, 1982] identified for a sensation of warmth.
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For the above reason the FCC should not adopt a standard with limits that exceed those of the NRPB (1986) in the millimeter and near millimeter range, e.g. above 6000 MHz.

Moreover, Gandhi et al. 1986 notes that as frequency increases and wave lengths shorten that near the upper end of the RF spectrum the heat in the skin for a gram of tissue may exceed, at least in principle, the proposed IEEE 1991 basic protection that localized heating should not for the skin be more than 20 fold allowed for the maximum limit for the whole body average. For example 10 millimeter waves may warm the skin 80 fold more than allowed for localized heating if IEEE 1991 limits are allowed, 8 fold higher if the EPA recommended limits are used, and 3 fold higher if the British National Radiological Protection Board limits are used.

Finally, it should be noted that reviews of papers study effects at millimeter waves, such as the approximately 14 millimeter related papers discussed in a 1986 review by the National Council of Radiation Protection and Measurement (NCRP), find biological effects which some may consider adverse for the millimeter frequencies, and justifies the finding that the NCRP limits are more science based than the limits of IEEE 1991 which are inconsistent with the references cited by IEEE 1991.

For those readers seeking further information some of these NCRP referenced papers, and some excerpts from them are given below.

This review is also provided because there was an opinion expressed in a letter to the FCC that there were few references in NCRP 1986 concerning millimeter and near millimeter waves, and that there was lack of linkage of these when setting exposure criteria [e.g. a letter dated March 4, 1996 to the FCC].

It should be noted that in the NCRP chapter 17 "Expsosure Criteria and Rationale" links with its previous discussions on millimeter waves, and it notes,

"There is however, no intent to define exposure criteria soley in terms of SAR (specific absorption rate). Consideration is also given to other factors where appropriate. These factors include the possibility of severe deviation from uniformity of energy deposition, especially at the __spectral extremes__ of frequency, ..." [NCRP, 1986, page 277, section 17.2.2.3] that in establishing this criteria it considered other factors besides the specif

Some Near Millimeter and Millimeter wave studies reviewed in NCRP. Note for convenience, the page number on which the article is discussed in NCRP is given in [ ].

Near Millimeter (6 papers, 3 of which were in a peer-reviewed journal)

1. Schwan, H.P. (1975) "Interaction of microwave and radiofrequency radiation with biological systems," pages 13-20 in Biological Effects ad Health Implications of Microwave Radiation: Symposium Proceedings, U S Public Health Service No. BRH/DBE 70-2

2. Schwan, H.P. (1977) "Classical theory of microwave interractions with biological systems," pages 91-112, in The Physical Basis of Electromagnetic Interactions with Biological Systems, Taylor, L.D. and Cheung, A.Y. Eds, University of Maryland.

"Schwan states that resonant interactions of biopolymers with electric fields area unlikely at frequencies below 100 GHz. Instead, relaxation effects have been observed. These relaxation effects are degenerated resonances due to the highly viscous properties of the water that suspends the biopolymers in vivo. Schwan discusses four regions of relaxation of the dielectric constant curve over the range of frequencies from a few kHz to 20 GHz." [discussed on pg 7-8 of NCRP 1986]

3. Prickard et al. (1979) "Developmental Effects of microwaves on Tenebrio: Influences of culturing protocol and of carrier frequency," Radio Science 14, 181-185.

Pickard and Olsen (1979) "The in-house colony (colony pupae) of pupaeP was maintained on ground Purina dairy meal and sliced potatos, and the outside cology (K pupae) was maintained on Kellogs Special K and sliced potatoes. All irradiation was administered in an anechoic chamber in the far zone of a standard-gain horn antenna at either 5.95 or 10.25 GHz. ...Exposures with the long axes parallel to the electric field produced no significant differences. Exposures with the long axes parallel to the magnetic fields had an injurious effect on the K pupae but not the cology pupae...There was some indication that irradiation produced teratogenesis" [in NCRP page 52]

4 Moore, W. (1968) "Biological aspects of microwave radiation: A review of hazards, U.S. Public Heatlh Service Publication TSB 68-4]

.Moore (1968) [for near millimeter study] "increased incidence of 'neoplasms of white blood cells' in mice ..exposed to 9.27 to 24.0 GHz fields at power densities of 20 to 100 mW/cm2. [discussed in NCRP pg 69]

5. Deichmann, W.B., Maile, J, and Landeen, K(1964). Effect of microwave radiation on the hematopietic system of the rat," Toxicol. Appl. Pharmocol. Vol 6, pg 71-77

"Deichmann et al (1964) studied the hematologic effects of various acute exposures on three strains of rats at a frequency of 24 GHz. Rats exposed at a power density of 20 mW/cm2 for 7.5 hours had increased red cell counts and hemoglobin concentrations, but decreased leukocyte counts. Differential leukocyte counts revealed a neutrophilia and lymphopenia.

The study was repeated, except exposure times varied from 7 min. to 5 hours, and results were similar to those of the first study, i.e. increased erythrocyte concentrations an neutrophilia and lymphopenia occurred regardless of exposure time

In another study, these workers exposed rats to 24 GHz fields at 10 mW/cm2 during a single 3 hours exposure or during six 3 hour exposures. The single exposure produced decreases in erythrocytes, whereas a modest increase occurred following multiple exposures. Following both exposure regimens, the concentration of circulating leukocytes was markedly decreased, neutrophils increased, and lymphocytes decreased." [no sham controls, and base line blood counts were obtained 2 days before exposure -could have been stress and handling says [NRCP page 69]

6 Deichmann, W.B. Bernal, E., Stevens, F and Lendeen, K (1963), Effect on dogs of chronic exposure to microwave radiation," Journal of Occupational Medicine Vol 5, 418-425,

Deichmann et al (1963) studied 2 dogs at 20 mW/cm2 at 24 GHz [in NCRP page 70]

Millimeter (from 1 millimeter in length to less than 1 centimeter in length) and infrared

1. .Rosenthal et al."Effects of 35 and 107 GHz CW microwaves on the rabbit eye," pages 110-128 in Abstracts of the Proceedings of the URSI/USNC Annual Meeting, Boulder Colorado (National Academy of Sciences, Washington DC [reference in NCRP 1986]

"The inverse relation between frequency and penetration depth has been demonstrated by Rosenthal et al. (1975) in an experimental study of effects on the rabbit eye exposed to 35- and

107-GHz fields. Effects of acute exposures at these frequencies were limited to the corneal stroma, indicating that maximal field absorption and heating occurred in the superficial regions of the eye, as predicted by theory. The 107 GHz radiation was found to be more effective in producing immediate stromal damage. The damage was repaired in 24 hours post exposure, in contrast to the effects of 35 GHz radiation, which was more persistent and was associated with a significant degree of epithelial damage.

At both frequencies, field-induced keratitis (inflamation of the cornea of the eye characterized by burning or smarting, blurring of vision, and sensitiveness to light) *occurred at intensitities lower than those required to produce other ocular effects such as iritis or lens opacification."* [in NCRP page 200]

A further reference is
Rosenthal et al. "Effects of 35 and 107 GHz CW microwaves on the rabbit eye," pages 110-128, in Biological Effects of Electromagnetic Waves, Selected papers of the USNC/URSI Annual Meeting Boulder Colorado, October 20-23, 1975, Vol 1 HEW Publication (FDA) 77-8010

2. Webb, S. J. and Stoneham (1977) "Resonances between 10^{11} and 10^{12} Hz (e.g. 100 to 1000 GHz) in active bacterial cells as seen by laser Raman spectroscopy" Physics Letters 60A, 267-268.

Webb and Stoneham 1977 "indirectly test Frohlich's theory by subjecting E.coli and B.megaterium to high frequency RFEM fields. They reported resonances between 75 GHz to 5000 GHz in living bacteria with an active metabolism, but not in resting cells, in cell homogenates or in nutrient solutions. They concluded that these resonances are the result of active in-vivo metabolic processes." [in NCRP pge 13]

3. Webb and Dodds (1968) Inhibition of bacterial cell growth by 136 gc (136 GHz) microwaves," Nature 218, 374-375.

Webb and Dodds (1968) "reported inhibition of cell growth in E.coli B when they used 136 GHz radiation, and in E. coli B_R at 61, 71, and 73 GHz." [in NCRP page 13]

4. Webb and Booth (1969) "Absorption of microwaves by microrganisms," Nature 222, 1199-1200
Webb and Booth 1969 "whereas 68 GHz fields stimulated growth." [in NCPR page 13]

5. Grundler, W, et al. 1977 "Resonant growth rate response of yeast cells irradiated by weak microwaves," Physics Letters 62A, 463-466.

"Grunder et al 1977 reported a resonant effect in the growth rate of yeast cells irradiated with CW fields at power densities of a few mW/cm2 at ~ 42 GHz... The authors believe that these results confirm the existence of resonant influences of coherent millimeter waves on biological properties and show alos the extreme narrowness of the frequency band for the response." [in NCRP page 13].

6. USSR Academy of Sciences (1974) "Scientific Session of the Division of General Physics and Astronomy," USSR (17-18 January 1973), Abstracts, Sov. Phys.-Usp. V16, 568-579.

"In addition to work in the Western world, the USSR Academy of Science (1974) has published a number of reports that are supportive of Frohlich's theories. Resonant effects were found in a wide variety or organisms and organelles. The millimeter band in the region of 5-8 mm was studied (60 to 37.5 GHz), often at low power densities. Unfortunately, more detail is needed if most of these experimental data are to be confirmed." [in NCRP pg. 14]

7. Illinger, K.H (1977) Millimeter wave and far-infrared absorption in biological systems," pages 43-66 in The Physical Basis of Electromagnetic Interactions with Biological Systems, Proceedings of a workshop, Taylor, L.D and Cheung, A.Y. Eds (University of Maryland, College Park, Maryland)

"Illinger (1977) has analysed the experimental data and theory relating to the millimeter and infrared range of frequencies and has suggested directions and caveats for future research [in NCRP pg. 14]...The coherent-regime frequency branch (~10 to 1000 GHz) which is associated with long range molecular interactions that lead to coupled biochemical reactions," [in NCRP pg 16]

8. Partlow, L.M. et al "Effects of millimeter wave radiation on monolayer cell cultures, I. Design and validation of a novel exposure system," Bioelectromagnetics 2, 123-140 (1981)

9. Stensaas et al. "Effects of millimeter wave radiation on monolayer cell cultures, II. Scanning and transmisson electron microsopy," Bioelectromagnetics 3 (or 2?), 141-150 (1981)

10. Bush, L.G. et al "Effects of millimeter wave radiation on monolayer cell cultures, III. A search for frequency specific athermal biological effects on protein synthesis" Bioelectromagnetics 2, 152-160 (1981)

(Partlow et al 1981, Stenasaas et al. 1981, Bush 1981) "The ultrastructural studies led the authors to the conclusion that changes, when found, were always associated with temperature elevations. Stensaas et al. (1981) drew the conclusion that, at the two frequencies used, 41.8 and 74 GHz, the changes seen were associated with hyperthermia." [pg. 34]

11. Blackman, C.F., Benane, S.G., Weil, C.M. and Ali, J.A. (1975) Effects of nonionizing electromagnetic radiation on single-cell biological systems, Annals of New York Academy of Sciences, Vol. 247, 352-366

"Blackman et al. 1975 have done some of the most carefuly controlled experiments with micorwaves at low power densities....No reduction was observed in viral titers when E.coli was infected with theta_x 174 and irradiated at 32 +/- 0.1 deg. C for 2 hours at 5 mW/cm2 using 68 to 74 GHz CW field...

"The only obvious effect of irradiation was an increase in rate of cell growth." [in NCRP page 35]

Blackman found growth to be affected by temperature changes as small as 0.2 deg. C [in NCRP page 36]

12. Chernovetz et al. (1977), "A teratological study of the rat: Microwave and infrared radiations compared," Radio Science, 12, 191-197 (Suppplement)

"Infrared-irradiated controls were employed by Chernovetz et al, (1977) who exposed Holtzman-derived, Sprague-Dawley rates to 2450 MHz fields at an SAR of 31 +/- 3 W/kg for 20 minutes [in NCRP page 56]

13. Hendler and Hardy 1960 "Infrared and microwave effects on skin heating and temperature sensation" IRE Trans. Med. Electronics ME-7, 143-152

14. Hendler et al. 1963 "Skin heating and temperature sensation produced by infrared and microwave irradiation," pages 211-230 in Biology and Medicine vol. 3, Hardy, J.D. Ed. Part 3 of Temperature: Its Measurement and Control in Science and Industry, Herzfield,C.M. Ed. (Reinhold Publishing Corporation, New York)

Hendler (1963) found if irradiate forehead (37 sq. cm) for 4 s, the mean abosolute power density threshold of warmth was.. 33.5 mW/cm2 and 3 GHz, 12.6 mW/cm2 at 10 GHz, and 4.2 mW/cm2 at 1000 GHz (far-infrared).[in NCRP page 237]

15. Vendrik, A.J.H. and Vos. J.A. (1958) "Comparison of the stimulation of the warmth sense organ by microwave and infrared irradiation," Journal of Applied Physics, Vol 13, pg 435-445

16 Justesen, D.R. et al. (1982), "A comparative study of human sensory thresholds: 2450 MHz microwaves vs far-infrared radiation," Bioelectromagnetics Vol 3, pages 117-125

Justesen et al. (1982) compares 2450 MHz and far-infrared and finds big drop in energy required for warmth (1.7 mW/cm2 on forearm. (107 cm2)...Because the thermal receptors are strategically located within the first millimeter of skin, they will be most efficiently stimulated by thermal energy that is deposited directly in their vicinity " [in NCRP page 238]

17. Michaelson, S.M. (1972) "Cutaneous perception of microwaves," Journal of Microwave Power, Vol 7, pages 67-73

Thermal studies of short wave lengths reviewed by Michaelson 1972 [in NCRP page 237]. "The shorter the wave length the less energy is required to provoke a just-detectible sensation of warmth." [in NCRP page 238]

18. Illinger, K.H. (1970), "Molecular mechanisms for microwave absorpton in biological systems," pages 112-115 in Biological Effects and Health Implications of Microwave Radiation, Syposium Proceedings, U.S. Pubic Health Service, No. BRH/DBE 70-2

"Internal rotation of terminal groups would be expected in the 10^{10} to 10^{12} Hz range (10 GHz to 1000 GHz). Amino and hydroxyl groups may be so affected, but hydrogen bonding may hinder this rotation.
Inversion transistions (-NH2) and ring deformations of non-planar ring systems may occur in the 10^{10} to 10^{14} range (10 GHz to 100,000 GHz)" [in NCRP pg 11]

Note: A recent review article by Belyaev (1992) finds biological effects (morphoses of cells) from millimeter waves with intensities as low as -0.1 mW/sq. cm.
Belyaev I.Y. (1992) Some biophysical aspects of genetic effect of low-intensity millimeter waves. Bioelectrochemical Bioengergetics Vol. 27, pg. 11-18

- **Power density for 100 MHz to 915 MHz is too high, and needs to be adjusted down:** Based on recent research by O. Gandhi (1992) the IEEE pwer density levels for the range 100 MHz to 915 MHz are now found to be too high, and need to be adjusted down to assure the meeting of the basic average whole body protection of the standard of 0.08 W/kg for the more restrictive tier, and 0.4 W/kg for the less restrictive tier.

It is understood that the dosimetry reference [B22, Durney (1986)] given by IEEE 1991 was that used to determine the power densities in IEEE 1991. Durney (1986) is not only recommended as a reference on IEEE 1991 pg.35, but referred to in the IEEE discussion of Whole Body Resonance. Therefore it is presumed Durney (1986) or a reference with similar information was used to determine IEEE 1991 power density limits to assure the basic provisions of the standard are met. See Exhibit 5 [Durney, dosimetry curves)

The main factor affecting SAR for different body types is the height and weight of one body size relative to another. Hence, if new research finds that the amount of power absorbed by the body is greater than previously thought, then having determined the more recent estimates for one body size, the other body sizes can be adjusted proportionately

Recently Gandhi et al (1992) published new estimates of the average whole body SARs for the frequency range 100 MHz to 915 MHz. The computer method used is called "finite difference time domain" (FDTD). It is interesting to compare Gandhi's computed SARs with those of the IEEE reference, and see what the SARs may be if Gandhi's results are applied to 1 year old children, e.g. if the earlier models of an adult were off by a factor of 2, then so too would be that of children -as a first 'guestimate' approximation, since an actual analysis by Gandhi on a 1 year old was not done. It is seen that using Gandhi's newer method that SAR are found to be about 2.6 fold higher than those in the IEEE dosimetry reference.

Frequency beyond the 'resonance' range	SAR per 1mW/sq cm. for an isolated model of an adult man Durney (1986)	an adult man Gandhi (1992)	Ratio	1 year old Durney (1986)	estimated 1 year old using ratio
500	0.033	0.0846	~2.6	0.08	0.21
700	0.032	0.0842	~2.6	0.07	0.18
915	0.031 (approx)	0.0825	~2.6	0.065 (approx)	0.17

Now a check can be made if the basic provisions to keep averaged whole body SAR below 0.08 W/kg can still be met using Gandhi's new estimates. For 915 MHz it is found:
power density allowed = 915/1500 = 0.61 mW/sq. cm
Predicted SAR = 0.61 mW/sq cm x 0.17 = 0.104 which is about 30% above the basic provison of the standard which is to keep average SAR below 0.08 W/kg.

Moreover, these estimates were made for a 1 year old child. A newborn will have a body size even closer to that of a 13 inch cellular phone wave, and so have even a higher SAR. Consequently, a newborn is predicted to have an SAR at proposed FCC power density limits that will even greater exceed the standard.

Additional observations include notice that the power density limits relating to SAR are the same in IEEE 1991 as in ANSI 1982, implying that either model building has only confirmed the earlier models upon which ANSI C09.1-1982 was based, or it was found convenient to not make changes, or some other reason. However, with the report of Gandhi it seems that a revision of the power density relationship to average whole body SAR is appropriate. Based on what has been shown above, it would seem to have the same SAR relationship to the standard as previously thought, that for the range 300 MHz to 1500 MHz, the formula should be

power density limit = Frequency/ (1500 x 2.6) = Frequency / 3900

Interestingly enough the 1986 National Radiation Protection Board standard for residential areas for the United Kingdom for 300 MHz to 1500 MHz was = Frequency /3750 (almost identical to that suggested above). It was reported that,

"The NRPB (1986) limits are basically consistent with ... ANSI (1982) guidelines. Some differences in detail exist, particularly with regard to the translation of basic limits (such as 0.4 W/kg SAR) into electric and magnetic field strengths and power denstities at various frequencies." [Gandhi,1990, pg. 21 and NRPB residential limits on page 22]

Hence, it seems, that the United Kingdom, has somehow developed an approach whose conclusion is the same of that as by Gandhi (1992).

Consequently, that the NRPB (1986) are using a formula very similar to that derived here, and given the need to be conservative, since NRPB (1986) is reported to use the same basic SAR limits, given the above, the FCC should adopt limts no greater than that of the NRPB (1986).

Note: that later it will be recommended that the FCC not adopt limits that exceed either those of the NRPB (1986) or those of Gandhi (1990, Table 3-5 pg 42]

- **Reject the proposed increases in exposures for the range 1500 MHz to 6000 MHz:** Increasing exposures for frequencies for personal communicatoins services, wireless cable and other frequencies above those of cellular telephones e.g. in the range 1500 MHz to 6000 MHz will undermine the basic provision protections of the standard and should not be considered.

1. These power density limits are inconsistent with the reference the standard gives for determining whether exposure levels meet the basic requirements of the IEEE standard

IEEE 1991 states that SAR is meaningful in the range of 3 MHz to 6000 MHz" [IEEE 1991 pg. 25], and, also, being somewhat inconsistent IEEE 1991 says SAR is meaningful in the range 0.1 MHz to 6000 MHz [IEEE 1991 pg. 22]. In either case, it is meaningful from 1500 MHz to 6000 MHz.

See Exhibit #6

However, if we refer to the dosimetry reference given by IEEE 1991, e.g the Radiofrequency Radiation Dosimetry Handbook, 1986 (IEEE ref. [B22], Durney 1986]) then IEEE recommended power density limits permit the basic absorbed energy protections of the standard to be greatly exceeded, being up to ***300%*** of the IEEE 1991 allowed whole body energy absorption limit for the general population of 0.08 W/kg [IEEE 1991, pg 25]. For example,

Example (1): for an average man at 6000 MHz
SAR per 1 mW/sq. cm = 0.033 W/kg
Power density allowed = 6000/1500 = 4 mW/sq. cm
Total predicted average whole body SAR = 4 mW/sq. cm x 0.033 W/kg = 0.132 W/kg which is 65% above the 0.08 W/kg which is the basic protection claimed by the standard.

Example: (2) At 6000 MHz, the Radiofrequency Radiation Dosimetry Handbook predicts the average whole body specific absorption rate (SAR) for each 1 mW/sq. cm of power density. The predictions for a 1 year old child is found in Figure 6.9. It shows that at 6000 MHz for an orientation of the body called "H" that a 1 year old will have an SAR of 0.06 for each 1mW/sq. cm. Now, IEEE 1991 allows 6000/1500 = 4 mW/sq. cm at 6000 MHz. Hence, the predicted SAR for H field orientation = 4 *0.06 = 0.24. But this is 3 fold (300%) of the allowed 0.08 W/kg. Hence the basic provision of the standard is exceeded.

Example (3): At about 2600 MHz, the frequency range for 'wireless cable' (Multichannel Multipoint Distribution Service) we find for a 1 year old child:
SAR per 1 mW/sq. cm = 0.07 W/kg from Durney 1986, Figure 6.9 as in example (1)
Power density allowed by IEEE 1991 = 2600/1500 = 1.7 mW/sq. cm
Predicted SAR = 1.7 mW/sq. cm x 0.07 W/kg for each 1mW/sq. cm = 0.119 W/kg which is 49% greater than the allowed 0.08 W/kg which is the claimed basic protection of the standard.

Example (4): for a 1 year old child at 1850 MHz (the low end of the frequency for Personal Communications Services)
SAR per 1 mW/sq. cm = 0.07 W/kg
Power density allowed = 1850/1500 = 1.23 mW/sq. cm
Total predicted average whole body SAR = 1.23 mW/sq. cm x 0.07 W/kg = 0.086 W/kg which is just about 8% above the 0.08 W/kg which is the basic protection claimed by the standard.

Hence, for a 1 year old child, at almost any frequency above 1500 MHz, applying the formula of IEEE 1991 results in a condition contrary to the basic provison of the standard. Moreove, if rates were computed for a newborn or any infant smaller than a 1 year old, since the body size would be closer to that of the 13 inch cellular wave, the SARs would be even higher. Hence, above 1500 MHz there should be no increase, otherwise from Durney (1986) which was the reference given by IEEE 1991, a violation of the basic provisions of IEEE 1991 will occur.

Thus, from the above 3 examples it is seen that the power density limits from 1500 MHz -6000 conflicts between the basic safety provisons of the standard

(2) Recent studies indicate absorbed energy levels are much higher than predicted by models used to develop IEEE 1991 and which appear now to overestimate what 'safe' levels of power density are needed to achieve the general provisions of the standard.

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Moreover, recent studies measuring absorbed RF power finds that much more power is absorbed that thought preivously in the U.S.

Hence, rather than an increase, instead a reduction in power at the these higher frequencies is required to provide the same basic level of protection on absorbed amount of power which the current FCC and proposed IEEE 1991 standard claim to provide. The 1986 RF standards of England or those recommended by one of the co-chairman of the IEEE 1991 committee would address this disparity that must be corrected.

(1) **As shown above, the power densities of IEEE 1991 are likely based on out-of-date relationships between SAR and power density, and need to be updated before proceeding with relaxation of power density criteria.**

Reject the relaxation of power density limits for partial body exposure, it is expected to make people feel very warm or hot, is incompatible with the standard with which it claims compatiblility, and is based on faulty logic, and a dangerous heating of the brain may occur.

(2) There is no compatibility between the proposed relaxation of power density limits for partial body exposure with the standard for "Safe Use of Lasers" [ANSI Z136.1-1986] applicable for shorter waves above those of radio-frequency-and which IEEE 1991 claims compatibility.

For example, the ANSI Z136.1-1986 states,

"For exposed skin areas exceeding 1000 sq centimeters (about 1 sq. foot) the MPE (maximum permissible exposure) is 10 mW per sq. cm (10 1/1000ths of a watt of power per sq. centimeter)." [Section 8.4.2, pg. 28]

In contrast, IEEE 1991does not have this limit for partial body exposures, but allows a partial body exposure for the general population that is up to 200% of the "laser" standard, while for the higher tier associated with occupational exposure IEEE 1991 has a partial body exposure that is up to 400 % the above laser standard.. As a consequence of IEEE 1991 exceeding this 'laser standard' IEEE can be expected to make people in the general population and the workplace feel very warm or hot.

Given that IEEE 1991 explicitly referenced this Safe Use For Laser standard in justifying its whole body exposure limit, it is unclear why IEEE 1991 then chose to violate this standard and allow up to 4 fold higher exposures than the Safe Use of Laser standard allows. The science based rationale for this is very unclear.

(3) Also, this partial body exclusion relaxation method shoud be rejected because it is based on faulty logic. It is known that some parts of the body if irradiated from a certain position may absorb 20 times more power than the average for the body. Accordingly, if power levels are increased by 20 fold, and if just that part of the body is irradiated and the rest of the body blocked by protective clothing so that it maintains the same contour, (and there is not a major contribution

of heating due to induced currents from other parts of the body), then the amount absorbed in that part of the body will be about 20 fold higher than before

For example, Gandhi et al (1992) computes specific absorption rates (SARs) for the body, by estimating the SARs in individual cubes of 1.3 cm per side, which will be about 1 gram of tissue. See Exhibit for an output showing the SARs when from a far distance the body was irradiated from the front at 915 MHz with a power density of 1 mW/sq. cm. Gandhi found that many cells of tissue by the front of the chest were over 0.6 W/kg (Exhibit gives SAR in mW/kg, so 0.6 W/kg = 600 mW/kg). For example in the first row of cells by the front 5 cells exceed 600 mW/kg (0.6 W/kg). It is easily seens that since the irradiation was from the front it is mainly tissue in the front that has high values of SAR (since 915 MHz does not penetrate more than one to two inches into the body). While some of the SAR may be due to induced currents from other parts of the body, because the chest is so wide, practically all of the SAR value is due to the direct irradiation.

Now, according to Table 3 of IEEE 1991 for Relaxations of Partial Body Exposures, for the more restrictive tier the power allowed is 4 mW/sq. cm. Since the output from Gandhi was based on 1mW/sq. cm, to predict what it will be based on 4 mW/sq. cm it is found that:
4 mW/sq cm x 0.6 W/kg (SAR at 1 mW/kg) = 2.4 W/kg. But for the chest tissue, the basic provision of the standard is that tissue should not have an SAR greater than 1.6 W/kg. Hence, using the method offered in IEEE 1991 will in this example result in a 50% excess SAR over that of the basic protection of the standard. Likewise, even greater excesses can occur. One cell in the figure (the cell is circled) has an SAR = 829 mW/kg or 0.829 W/kg. If a power density of 4 mW/kg is applied then the SAR = 3.3 W/kg which is over 200% of the allowed 1.6 W/kg. Hence, the method proposed in 4.4 apparently does not always apply. It should be rejected and the FCC should not adopt this provision

Indeed, even the basic logic for the IEEE method seems unusual. Since, in general, tissue closest to the incomming radiation can often be expected to have SARs much higher than the average SAR for the body (as in the above example), it seems quite unusual to suggest that if just a part of the body is irradiated then exposures can 'automatically' be 4 times to 20 times higher. It may be that the entire approach needs to be re-thought

Incidently, that no documentation is given for the methods used to derive these limits is an important deficiency, especially since it appears the method does not work. This entire section should be rejected by the FCC and rely on current FCC rules which provide for a case by case review to determine if basic protections are maintained.

(4) A dangerous heating of the brain may occur if IEEE 1991 partial body power denisty limits are allowed. This is suggested by the findings in a near millimeter wave study in the IEEE final list paper [Deichmann, 1959, IEEE pg. [illegible]] in which there was a partial body exposure to the back of the head of laboratory rats at power density levels only 20% above that proposed as 'safe' in IEEE 1991 for partial exposures to the general population for 12.5 millimeter waves. At this level, after 24 minutes there was ***a 1 degree centigrade increase in the brain,*** just below the skull. While the human skull is thicker than a rat's, bone has little water content and so RF can more readily penetrate it than skin or muscle. Hence, it is not clear, if over a sufficient time the brain of a person may become to warm.

Electric field limits need to be adjusted to assure children and adults in the general population do not get RF burns or shocks from grasping contact based on limtis given in the standard. Prevention of electric shock and RF burn when grasping must be assured when children or adults in the general population grasp the metal handles of vans or metal parts of busses must be assured by having the electric field limits for the more conservative tier (for the general population and RF non-technical employess) compatible with the electric fields which would not cause a violation of the standard's limits for induced or contact currents or RF burn for this tier. The limits should be based on the common large metallic objects found among the general population: eg. buses and vans.

The FCC electric field and power density limits should not exceed those specified by [OP Gandhi 1990, Table 3-5 - the magnetic field limits should NOT be used]

Reject the limits for the higher tier in IEEE 1991 to protect workers from RF burns and high induced and contact currents. The standard itself recognizes that protection is not provided at this level. IEEE final list referencces also document the limits are too high. Apply the same limits as for the general population as the human body is the same, as recommended by Dr. Gandhi one of the co-chariman of IEEE 1991 [Gandhi, 1990, pg. 44] Gandhi notes,

"Identical current limitations are proposed for both occupational and public exposures. Since safety measures canbe adapted in the work place, higher field limits are suggested provided steps are taken to limit the currents for contact and non-contact situations."

Reject limits that only provide a 10 year old child protection from RF startle or shock from "grasping" contact but not "finger contact": A 10 year old child should not fear a startle response, from finger contact with a school bus. Hence, it is not enough to protect against RF burn from "grasping" contact - protection from RF burn from finger contact is needed too. The electric fields must be below the level of perception by way of finger contact of a 10 year old child touching a school bus. The IEEE final list papers providing these electric field levels shoud be used, as was recommended by one of the co-chariman of IEEE 1991, who computed the necessary limits. No higher than these limits should even be considered by the FCC.

The above requirement can be met by the following recommendation. The FCC should not adopt exposure criteria that exceed those recommeded by [Gandhi 1990, Table 3-5, pg 42 (accept the magnetic fields are too high so keep the current FCC limits when they are lower)]

Do not allow the general population or workers to be subjected to the potential annoyance and stress, and possible permanent adverse effects of chronic mircrowave hearing
The EPA reports,

"Pulsed RF radiation can be perceived ("heard") by some people. The perception of sound varies with pulse width and pulse-repetition rate and is described as a click, buzz, or chirp...Although the effects of RF hearing on health are not now known, the experience can be annoying and stressful." [EPA, 1986, pg. 27327]

The annoyance and stress of such clicks, buzzes or chirps is deliterious to the quality of life and can lead to accidents due to annoyance and stress. Also the long terrm effects of the rapid thermoelastic expansion of the brain exciting the hairs of the cochlea which causes this effect is unknown and may be hazardous.

Morevoer, it is disturbing, that concerning this problem. IEEE 1991 states that its limit on peak power,

> "..*is well* ***above*** *the threshold for auditiory effect. The latter is clearly* ***not deleterious.***"

The above is disturbing, because one wonders what is the criteria of IEEE 1991 to determine that a factor which is expected to be annoying and stressful to some people, and perhaps affect their concentration, work, learning, or performance is "not deleterious." Moreover, one wonders on what scientifc basis IEEE can state it is "clearly" not deleterious, since it also acknowledege a lack of chronic exposure data. Since the effect is due to a rapid thermoelastic expansion of the brain, how does IEEE 1991 know "clearly" that such chronic expansion of the brain and chronic stimulation of the auditory nerve is not deleterious? Also, such a view of IEEE is contrary to that of EPA which above states more appropriately that the long term effects "are not known."

One way it may be hazardous is that chronic stimulation of the hairs of the cochlea may result in chronic stimulation and, and perhaps chronic induced currents of the acoustic nerve, which may have adverse effects. Susan Preston-Martin, an epidemiologist at the University of California at Los Angeles has found that persons in occupations with exposure to noise are at higher risk to get tumors in the region of the acoustic nerve.[noted by R. McGaughy of the EPA in Federal Focus Cellular Telephone Research and Cancer Symposium, Dec. 1993, and in WTR, 1994]

Reject the proposed increases in the magentic field levels which are up to 100 fold greater than the current FCC standard and exceed international standards and some proposed U.S. non-federal standards for 60 Hz exposure, and are contrary to the health policies of the U.S. Dept. of Energy, those of states and other countries, and contrary to the findings of some experts in this field.

Consider that an object about 35% to 40% the length of an electromagnetic wave best absorbs its energy. Thus, for the 3000 mile long wave from electric power lines almost none of its energy is absorbed. Yet there are indications they may sometimes have detrimental effects, even at very very low "non-thermal" levels. Hence, for the magnetic field, its thermal effects may not be relevant.

Consequently, RF which is a much shorter wave, can be better absorbed by people, and hence there is a potential that even very low intensity RF magnetic fields may be efficiently absorbed by the body and be a potential health risk, especially if it is pulsed or surges in a manner similar to the surging of 60 cycle electric power line fields.

"Prudent avoidance" is now a policy being supported at the U.S. Department of Energy (DOE) and the National Institutes of Environmental Health Sciences (NIEHS), as evidenced by contracts being funded to learn in what ways exposures from power line EMF fields can be reduced. Hence, it seems FCC must be given a very strong justification before it should allow any increase in a magnetic field strength. Indeed, a panelist at a 1993 EPA RF conference said,

See Exhibit 2 + 8

"..*the diffence between the internal fields from "direct ELF (e.g extremely low frequency from power lines) and fields generated from RF radiation, where the latter fields are much greater (by as much as 100,000 times. Thus, the panelist noted, the internal ELF fields from ELF modulated RF radiation may be more significant than from direct ELF. Another panelist commented that effects due to ELF-modulated RF radiation that are similar to direct ELF fields have been observed experimentally, although the results have not been conclusive.*" [Panel 1: Exposure and Dosimetry, pg. 15-16, EPA 402-R-95-009] See Exhibit #2

How much is a lot? Consideer a 12 mG (milli Gaus) magnetic field blocked the protective action of the hormone melatonin from inhibiting the growth of breast cancer cells in culture. Recently this experiment was replicated. Also, a draft NCRP report on ELF frequencies just recommended a goal of 2 mG.

In contrast current FCC limits allow magnetic fields as high as 19 mG from .3 to 3 MHz. The proposed limits will allow about 2000 mG from 0.003 to 3 MHz. Hence, instead of raising limits by about 100 fold, the FCC may begin to inquire about whether they may be reduced.

The only justification given in IEEE 1991 for the increase is that this would be no more than 1/20th of the general population basic limit for average whole body specific absorption of energy. This reason is insufficient. It complete ignores any discussion of ELF modulated effects (in part because IEEE1991 denies the existence of these effects]. Also, in this report it was shown that adverse disruption of a learned skill ocurred at this level, and that this may justifiy lowering FCC limits to 1/20th of their current level. Hence, this justification is unsatisfactory and should not be accepted.

[Liburdy, R.P et al. (1993) ELF magnetic fields, breast cancer and melatonin: 60 Hz fields block melatonin's oncostatic action on ER+ breast cancer cell proliferation," Journal of Pineal Research, Vol 14, pg. 89-97].

- Many of the IEEE claims of 'conservative assumptions' or implicit contributions toward safety should not be accepted or in the FCC standard - they often are not applicable, especially for young children or for the cellular phone and higher frequencies. This is because:

(1) IEEE states behavioral disruption is not a defined hazard - on the contrary, having the central nervous system impaired so learned responses or the learning of new tasks is impaired is deleterious, as any educator or employer will affirm. Moreover, as has been shown, many adverse effects occur below the IEEE hazard threshold, and federal agencies indicate its protection is uncertain.

(2) IEEE suggests man's "superb thermoregulation" adds further protections. But this is only valid if the hazard is a thermal hazard. Some of the adverse effects noted occurred at levels below 1/100th of the IEEE hazard threshold. Even on a microscopic level if there is a thermal action, it is not clear that man's thermoregulatory system will provide protection.

(3) IEEE states the standard limits are based on the "E" orientation of the body which is the "worst case." This is only so for the frequencies between about 30 MHz and 300 MHz. Indeed, for cellular frequencies and higher, often another body position "H" results in the "worst case exposure" and not "E" [based on rough estimates reported in the dosimetry reference, the

Radiofrequency Radiation Dosimetry Handbook, recommneded by IEEE 1991 (reference [22]). For example, at 3000 MHz (near the 2600 MHz for 'wireless cable'), a 1 year old child is estimated to absorb 40% more energy when in the "H" orientation than in the "E" orientation. While this is based only on rough estimates, it illustrates that "E" is not the "worst case" as suggested. But indeed, for the higher frequencies using the "E" orientation could underestimate the worst case exposures. It would seem a more protective approach would be using the worst case position at each frequency, even if it is different from frequency to frequency.

(4) IEEE claims the incorporation into one contour for all human sizes is a conservative measure. This is correct for the conditions for which average whole body exposure is relevant. The 'hot spot' range for the human head is 300 MHz to 2000 MHz, with the optimum 'hot spot' area occuring around 915 MHz, near the cellular phone frequencies. The limits computed do not address 'hot spot' issues, and even allow power intensity to increase as frequency increases from 300 MHz to 915 MHz, even though 'hot spot' regions in the head may increase as the optimum 915 MHz frequency is approached.

Moreover, many of the wireless applications are being planned for above 6000 MHz, at which point IEEE 1991 states that SAR is no longer meaningful, and then surface power density becomes the appropriate parameter [IEEE 1991, pg. 22]. Hence, there are considerations for which body contour may not be relevant. Finally, for the wireless frequencies at cellulalr and up to 6000 MHz, infants, especially newborns are at greatest risk - and these may be the most vulnerable to stress - so for these body contour provides no implicit protection.

In its "Rationale" IEEE 1991 makes certain claims that are incorrect and should not be adopted by the FCC. IEEE claims that "no reliable scientific data exist indicating that"

1- Certain subgroups of the population are more at risk than others,
2- Exposure duration at ANSI C95.1-1982 levels is not a significant risk,
3- Damage from exposure to electromagnetic fields is cummulative,
4- Nonthermal (other than shock) or modulation-specific sequelae of exposure may be meaningfully related to human health.

That all of the above are false claims can be seen by selecting a few counter-examples from the IEEE final list of papers which were carefully reviewed by an IEEE 1991 subcommittee for being papers providing "reliable scientific data". While additional examples could be given, since IEEE 1991 agrees that its final list of papers provides "reliable scientific data" these examples shall be limited to them, with one partial exception being #1

Please remember, there is no attempt here to conclusively prove any consistent pattern. Rather, the intent is only to demonstrate that indeed there does exist "reliable scientific data" providing indications that certain phenomena exist.

#1. Subgroups of the population more at risk than others for the wireless services frequencies includes:
- infants since there bodies are closer in size to the wave lengths of cellular phones and higher frequency services per IEEE dosimetry reference [22]